# Devils in the details

January 28, 2020

Originally published December 12, 2019

**By Whitney Spivey**

In July 2016, Wendy Strohmeyer, the Bradbury Science Museum's then-newly hired collections specialist, was sorting through a backlog of artifacts in the museum's warehouse. "A small stack of plain brown boxes full of donations had piled up," she remembers. "As soon as I felt ready, I began going through them."

In the bottom of one box was a large ziplock bag. Inside the bag were 13 corroded, dirty, hollow metal cylinders with "handlebars" protruding perpendicularly from one end.

*Thirteen Manhattan Project–era exploding-bridgewire detonators were discovered in a backlog of artifacts at the Bradbury Science Museum. "We have less Manhattan Project artifacts than you'd think," says collections specialist Wendy Strohmeyer. "I think it has to do with the ration-conserve-reuse mentality at the time…anything that is a direct relic of that time is very valuable to the museum."*

Unsure of what the roughly baseball-sized artifacts were, Strohmeyer called weapons engineer Glen McDuff. "Wendy calls me about anything strange she finds," McDuff explains. "I'll go over and see it. If I can, I'll tell her what it is."

In this case, McDuff was able to tell Strohmeyer that she was in possession of 13 empty (no explosives) exploding-bridgewire detonators from the Manhattan Project—yes, that 1940s top-secret effort to build the world's first atomic bomb. These handlebar detonators or 1773 detonators, as they're also called, were the same type of detonators used in 1945 in the Gadget, the atomic device detonated in the Trinity Test, and in Fat Man, the atomic bomb used on Nagasaki, Japan.

"I think they represent something bigger than being part of a weapons assembly," says Laboratory engineer Daniel Preston, who has worked for the Lab's Detonator Science and Technology group. "If you apply the right historical lens, they show how special Los Alamos is."

Finding the correct historical lens was tricky, even for Preston, who is both an accomplished detonator designer and a history buff. "At first glance, these artifacts look like empty detonator bodies," he explains. "A closer inspection reveals that these parts were once filled with explosives and fired."

*Detonator specialist Daniel Preston examines the 13 exploding-bridgewire detonators from the Bradbury Science Museum.*

But wait a minute. Detonators are supposed to detonate, destroying themselves; how did these 13 remain intact? Preston believes they are the remains of classic detonator threshold testing. “Threshold testing is performed by firing a series of detonators at a variety of voltage potentials (electricity sources) and observing whether the detonator ‘goes,’” he says. “In threshold testing, by design, half of the detonators do not fire properly because they do not get enough energy; we call these NoGos.” Often, NoGos will burn all their explosives, leaving an empty detonator with the faintest trace of deformed metal.

If the Bradbury’s detonators are in fact remnants of Manhattan Project–era threshold testing, then they directly supported the Trinity Test and the Nagasaki mission by helping scientists dial in the appropriate voltage for the detonators on the Gadget and Fat Man.

“Holding these detonator parts is like holding little time machines,” Preston says. “Their existence highlights how Los Alamos and its workforce changed the world.”

## What is a detonator?

Detonators are small devices used for detonating a high explosive. In a nuclear weapon, the nuclear part (called the core or the pit) is surrounded by high explosives. The detonation of those high explosives is what causes the pit to implode (compress) and create nuclear yield. To ensure this compression happens evenly around the pit, the detonators (there are many per weapon) must go off at exactly the same time.

“To get a uniform implosion, you needed to start it detonating in a large number of places with a very high degree of simultaneity,” now-deceased physicist Lawrence Johnston explained during an interview at the Institute of Electrical and Electronics Engineers in 1991.

During the Manhattan Project, Johnston and his mentor, Luis Alvarez (who would go on to win the Nobel Prize in 1968), designed a new type of detonator, the safe and reliable exploding-bridgewire (EBW) detonator—the same kind that McDuff identified for the Bradbury.

Although Johnston and Alvarez were the brains behind the detonators, the devices were built mostly by women because of the dexterity required for detonator construction. “Women were brought in from nearby pueblos to do the assembling and loading, and SED [Special Engineering Detachment] soldiers were in charge,” Johnston explained. “Those women got real good at soldering the bridgewires on the entrance plugs and loading the explosives.”

*The original EBWs (as drawn here) are often called 1773 detonators. 1773 refers to the drawing number.*

In this type of detonator, an electrical charge from a capacitor heats a bridgewire—a hair-thin wire that’s tucked into an explosive inside the detonator’s handlebar. Preston says there’s still some mystery to what’s going on inside an EBW detonator, but the current theory is that the bridgewire heats up so quickly that it vaporizes and creates a shock wave that detonates the explosive inside the handlebar. Combined with all the other small but powerful explosions from the other detonators, this explosion, in turn, detonates the adjacent high explosives that surround the weapon’s plutonium pit. The pit implodes, creating nuclear yield.

The EBW design was critical to the safety of nuclear weapons because an EBW requires a specific energy source (electricity) to detonate, reducing the possibility of an accidental explosion.

EBW detonators were used on the Gadget, the world's first nuclear test, on July 16, 1945, near Alamogordo, New Mexico. "Praise the Lord, my detonators worked!" Johnston exclaimed after the Trinity Test. "I'm sure there were a number of people there who had been responsible for some essential component of the bomb, who felt the same elation. If the bomb had fizzled, [each man] would have had dark thoughts that maybe it was his fault."

After the Gadget's demonstrated success, EBW detonators were used on Fat Man, the atomic bomb that was dropped on Nagasaki on August 9, 1945, to help end World War II.

"We saw the flash of the Fat Man bomb come in through the window," remembered Johnston, who saw the explosion from a nearby observation plane. "Again, my detonators must have worked!"

## Detonators today

After World War II, the Atomic Energy Commission moved detonator production from Los Alamos to Mound Laboratories, in Miamisburg, Ohio. But when Mound was declared a Superfund (contaminated) site in 1989, detonator production was moved back to Los Alamos.

After all these years, the EBW design is still used, although today's EBWs are about the size of a pencil eraser.

*A modern EBW (left) is much smaller than a 1940s-era EBW (right).*

The Laboratory's newest detonators are called chip slappers. Like EBWs, chip slappers use an electrical charge to vaporize material and a shock wave to initiate an explosive. Whereas an EBW has the bridgewire embedded in the explosive, slappers separate the bridge from the explosive with an air gap and an insulating film. The vaporization of the bridge throws the film across the air gap into the explosive, "slapping" it. This separation of explosive and electrical components improves safety.

"Chip slappers are very efficient and very safe," Preston says. "They need a specific signal for the chip to vaporize and slap the explosive." Chip slappers are also more manufacturable and smaller than EBWs.

In fact, because chip slappers are so safe, they are replacing EBWs in America's B61 nuclear gravity bombs. "It's not a trivial thing to change the detonator in a nuclear weapon," Preston says. "It's a hard problem to put a new technology into an existing weapons system." But as the B61 gets upgraded for another 20 years of service, it's important to have components that age well and are resistant to temperature fluctuations.

"Having the right kind of detonators to use in nuclear weapons is a high bar to meet, and Los Alamos continues to 'answer the mail' on them," says Preston, meaning that the Laboratory is continually inventing better—safer—detonators.

*Presses are used to progressively bend or cut features in a sheet of aluminum until it forms a three-dimensional cup that will ultimately be loaded with high explosives and placed inside a detonator.*

Preston is also quick to point out that “it takes an elegant engineer to make a good detonator,” referring to how devilishly hard it is to design and build this tricky little piece of equipment. “The devils are in the details.”

Because electricity has always been the riskiest element in a detonator, Los Alamos has started creating detonators in which the electrical energy is replaced by high-intensity laser energy. These detonators are known as optical detonators.

“The biggest advantage of going optical is the unique energy source required to set off the detonator,” says Mike Bowden of Q-6, the Los Alamos Detonator Design Agency, who designs optical detonators. “Rather than having an electrical pathway to detonation, an optical detonator relies on a small, robust laser, removing all electrical means of detonation. Los Alamos will produce the safest and most robust and reliable detonators the world has ever seen.”

Not only that, optical detonators will be even smaller than a modern EBW, making them a tiny piece of the safest, most reliable nuclear weapons in the world.

## Devil drawings

*1. Inventory, bonded storage, and receipt inspection persist as the best technical and business practices for detonator design and production.*

*2. A bridgewire is soldered between the terminals. The gap between terminals dictates the length of the bridgewire.*

*3. Devils perform the dexterous task of soldering the bridgewire to the terminals and cutting the excess off the core.*

*4. Devils compare components to design requirements.*

*5. The bridgewire and core form a complete circuit.*

*6.High-electrical potential (hipot) testing is performed to test the cores for electrical isolative properties.*

*7. Detonator parts must be clear from foreign object debris (FODs). FODs can cause safety issues when loading explosives.*

*8. Grease and oils can cause explosives to not age well; cleanliness is paramount to detonator fabrication.*

*9. Detonator assembly involves many processes; no short cuts can be taken.*

*10. Devils perform mechanical checks to ensure detonators will function.*

*11. Detonators must be meticulously packaged into packaging and transportation containers.*

*12. Detonators are disassembled and surveilled at different stages to better understand how they age.*